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VII-3. FIELD BEHAVIORAL RESPONSE AND BEAD FORMULATIONS FOR METHYL ANTHRANILATE ENCAPSULATED BIRD REPELLENTS

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INTRODUCTION

The concept for an encapsulated form of the bird repellent methyl anthranilate (MA) for use in wetland settings was developed previously (Clark and Cummings 1992). MA was encapsulated in gel-alginate capsules, which were broadcast over the surface of natural sediments at Eagle River Flats. The capsules were designed to remain relatively stable for short periods of time, until they were picked up by foraging ducks; the capsules would break under normal bill pressures found during filter feeding. Two formulations were tested, one each during the spring and fall of 1992. Sites were established in Areas B and C, and enclosure studies on captive mallards were initiated to evaluate the degree of feeding suppression resulting from the use of MA beads. The formulation SE92, which consisted of a food-grade silicone oil as an internal matrix, inhibited feeding activity for up to 7–10 days. The degree of feeding suppression and length of effectiveness varied as a function of water depth. The formulation DP920324B was developed to minimize the harmless, though unsightly, oil leakage characteristic of SE formulations. However, the DP formulation was not effective at suppressing feeding activity. We attributed the failure of the DP formulation to the increased size and the breaking pressure needed to release the repellent. The main objective of the 1993 field season was to find a formulation that would provide suitable repellency and optimal characteristics of stability. A secondary objective was to determine whether ducks could be moved off a treated area and whether feeding activity would reflect the substrate conditions, i.e. lower feeding activity on treated surfaces and increased feeding activity on control surfaces.

SPRING 1993

Materials and methods

As in previous field seasons, sediment samples were taken in Area C surrounding and including the pen enclosure sites to verify the presence of white phosphorous (WP) in the substrate. Samples were taken and analyzed for WP using methods previously prescribed by CRREL. Within Area C, pens were positioned so as to include at least one WP sampling point. This point was used as a crude index of WP exposure for feeding ducks. We acknowledge that WP distribution is variable spatially, and our sampling points may not reflect the integrated, spatially dependent risk foraging ducks encounter.

Mallards were captured in Denver, CO. Mallards were baited with cracked corn and grain and captured with cannon nets (SOP WRC-198). Ducks were captured under Federal permit PRT-68014 and state permits for Colorado, 92-0060. Ducks were banded with USFWS leg bands (SOP WRC-404) and were transported to Fort Richardson for testing via air freight.

Upon arrival by air freight, ducks were housed in holding pens (six per pen) and quarantined for a minimum of ten days. To prevent ducks from leaving the open test pens, primary feathers 2–9 on the right wing were clipped. Ducks were weighed with pesola spring scales (WRC-204.R3) and ranked according to weight. To minimize harassment, ducks were assigned to pens based upon similarities of weight. Thus, the six heaviest ducks were assigned to one pen, etc. Pens were randomly assigned to treatment. At the end of field trials, two ducks from each group were sacrificed for WP analysis. The remainder of surviving ducks were returned to DWRC.

Mallards dying during the course of the experiment were deep frozen and reserved for tissue necropsy and residue testing for WP. Any animals exposed to the WP areas were sacrificed (SOP WRC 245.R1) and necropsied. Carcasses were frozen on site and shipped to DWRC packed in dry ice and styrofoam containers via one-day air freight delivery for necropsy. After necropsy, carcasses were incinerated at DWRC (WRC-233.R2, Use of incinerator).

We monitored behavior and determined the risk of mortality for feeding ducks. The day prior to a pen's first scheduled observation, encapsulated MA was broadcast over the surface of the sediment at a rate equivalent to 40 lb/acre. Enclosures were 60 × 30 ft. One half the enclosure was treated with MA beads, while the other half remained as a control. Six ducks were placed in a pen for a two-hour observation period. Ducks were placed in pens at 24, 96 and 168 hours after deposition of the beads. Observations were made every 30 seconds for the duration of the two-hour observation period from a tower/blind. The positions of the ducks within the pen and the number of ducks feeding were noted at the specified time intervals. A total of six pens (two per day) were observed. After each pen was observed for the third time, the substrate was retreated with the original application rate of beads, a naive set of ducks was introduced and observations recorded according the methods prescribed above.

After the two-hour observation period, ducks were removed from the field pens and returned to the holding pens. Ducks were periodically observed for the next 24 hours to determine if any latent toxic effects were present. Mortality was attributed to WP poisoning if the patterned distress behavior was observed in the field or holding cages and if necropsy confirmed the presence of WP in the crop or gizzard. All necropsies were carried out by CRREL personnel, who were blind to the identity of sampled ducks.

Results and discussion

The high degree of heterogeneity for feeding activity and cage-side preference is reflected in Figures VII-3-1 and VII-3-2. However, there is a general tendency for ducks to shift their site preference away from the area of the pens treated with MA beads as a function of experience (Fig. VII-3-3 left and VII-3-4 left). Similarly there is a tendency for feeding activity to decrease at a faster rate within the bead-treated areas relative to the control substrate areas (Fig. VII-3-3 right and VII-3-4 right). Why ducks tend to decrease feeding activity as a function of experience is not addressed directly by these data. However, previous observations derived from uniformly treated pens showed that feeding decreases over the active life of the MA beads, while feeding activity remained independent of time for controls. The inhibition of feeding activity in pens where beads and controls are simultaneously present suggests that there is a short-term, near-spatial carryover effect of treatment.

The life span of the beaded formulation depends on the extant local environmental conditions. If the beads are suspended within the water column near the surface, the MA disappears from the bead quite rapidly (Fig. VII-3-5 top). For all practical purposes the beads are depleted of effective levels of MA within 24 hours. Presumably the main factor responsible for the disappearance of the MA is diffusion through the matrix wall. Deposition of the beads into the

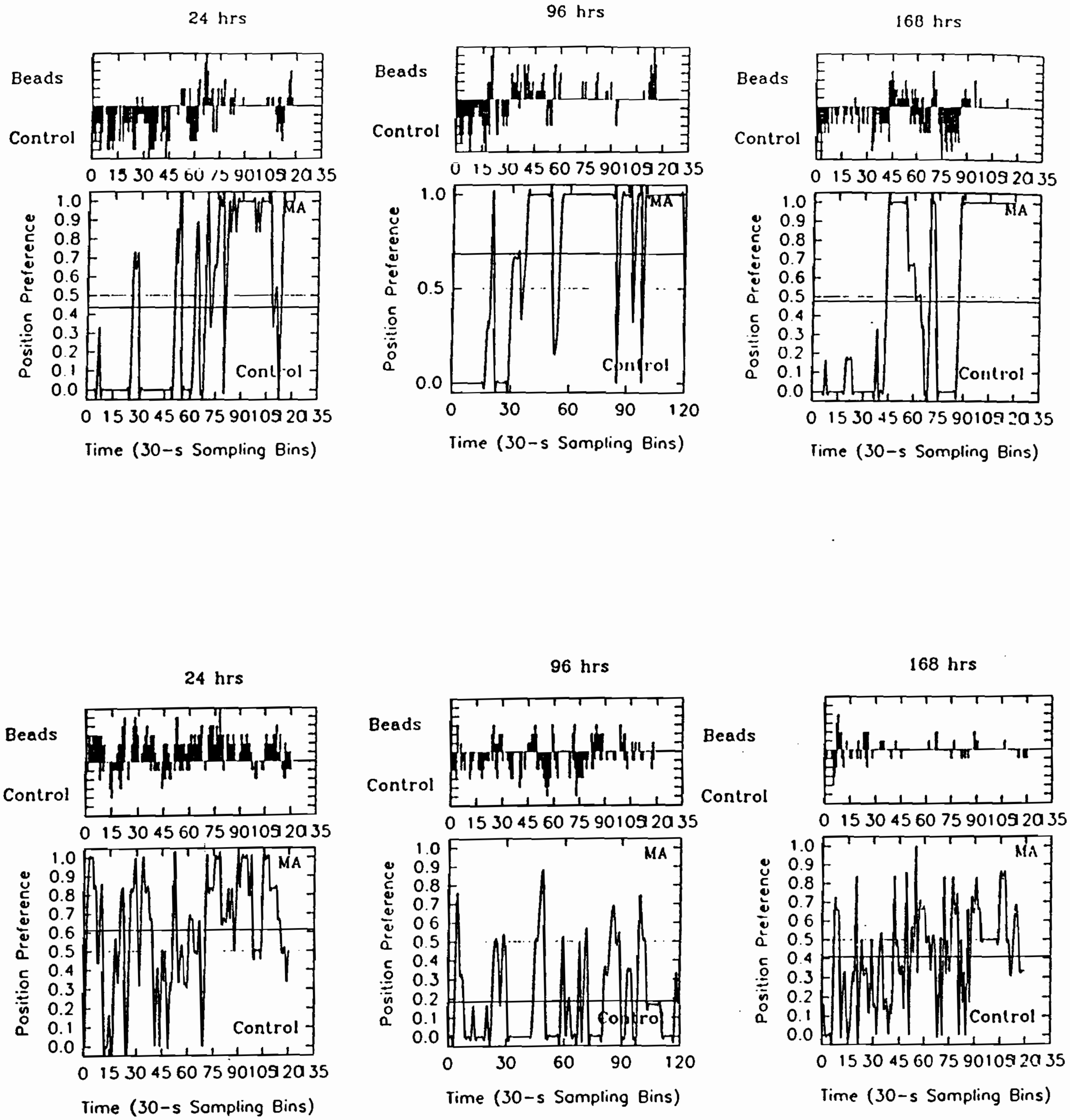


Figure VII-3-1. Behavioral records for the first treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA beads. Negative values reflect the feeding intensity in the untreated portion of the pen. (Bottom) Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of 0 indicates that all ducks were on the control side. A score of 0.5 indicates that half the ducks were on either side of the pen.

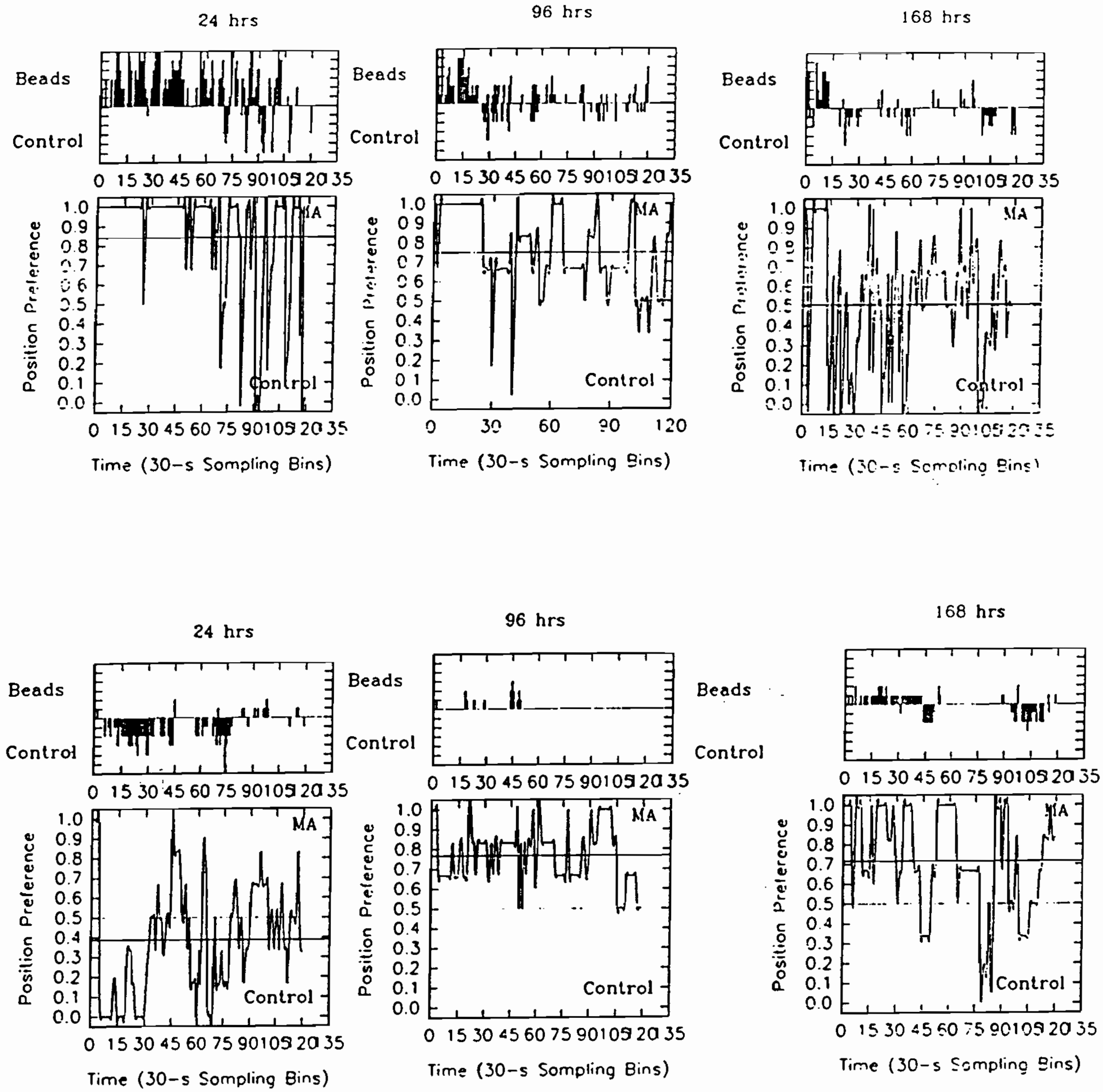


Figure VII-3-1 (cont.). Behavioral records for the first treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA beads. Negative values reflect the feeding intensity in the untreated portion of the pen. (Bottom) Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of 0 indicates that all ducks were on the control side. A score of 0.5 indicates that half the ducks were on either side of the pen.

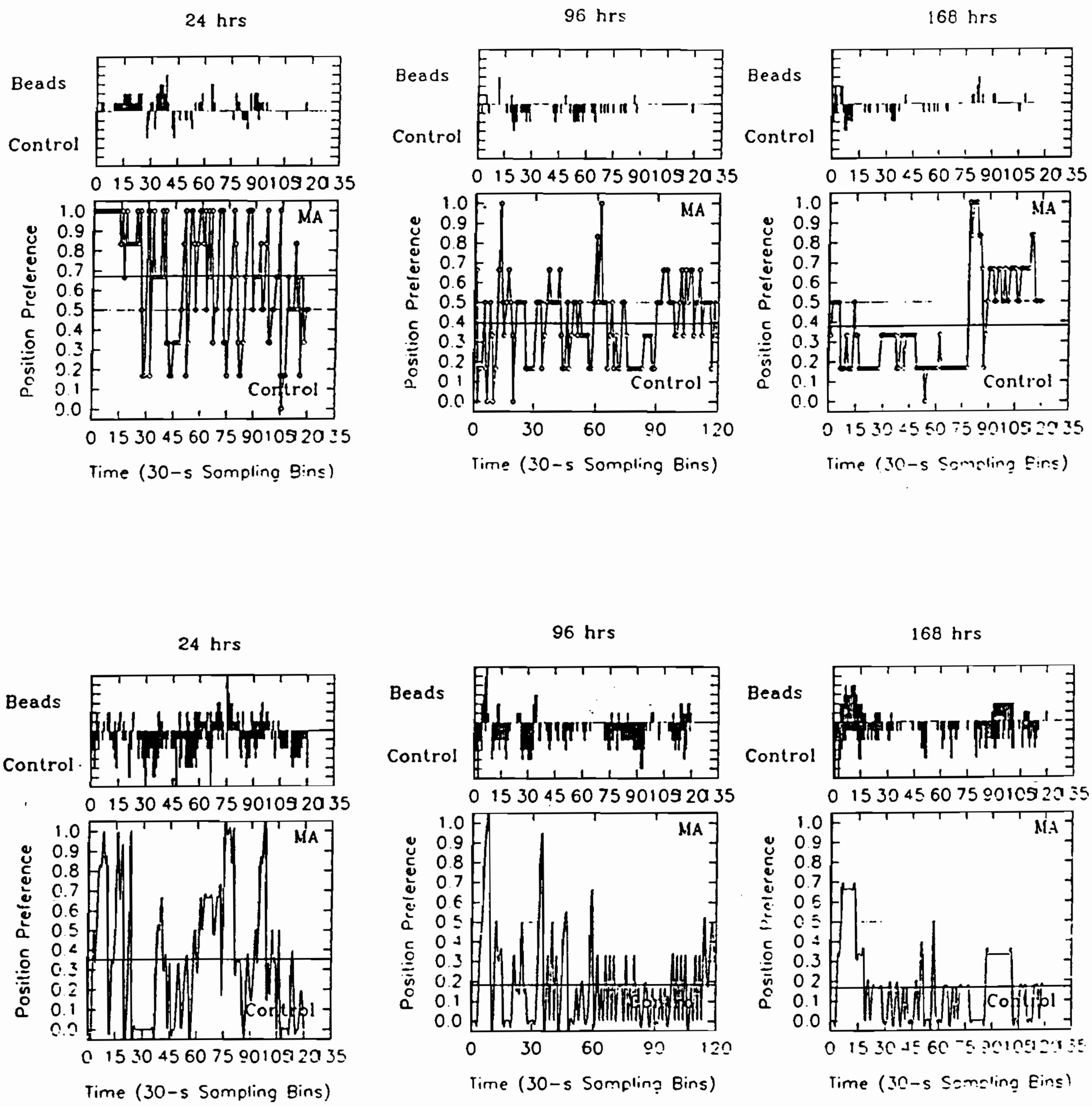


Figure VII-3-1 (cont.). Behavioral records for the first treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA-beads. The negative values reflect the feeding intensity in the untreated portion of the pen. Bottom. Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of zero indicates that all ducks were on the control side. A score of 0.5 indicates half the ducks were on either side of the pen.

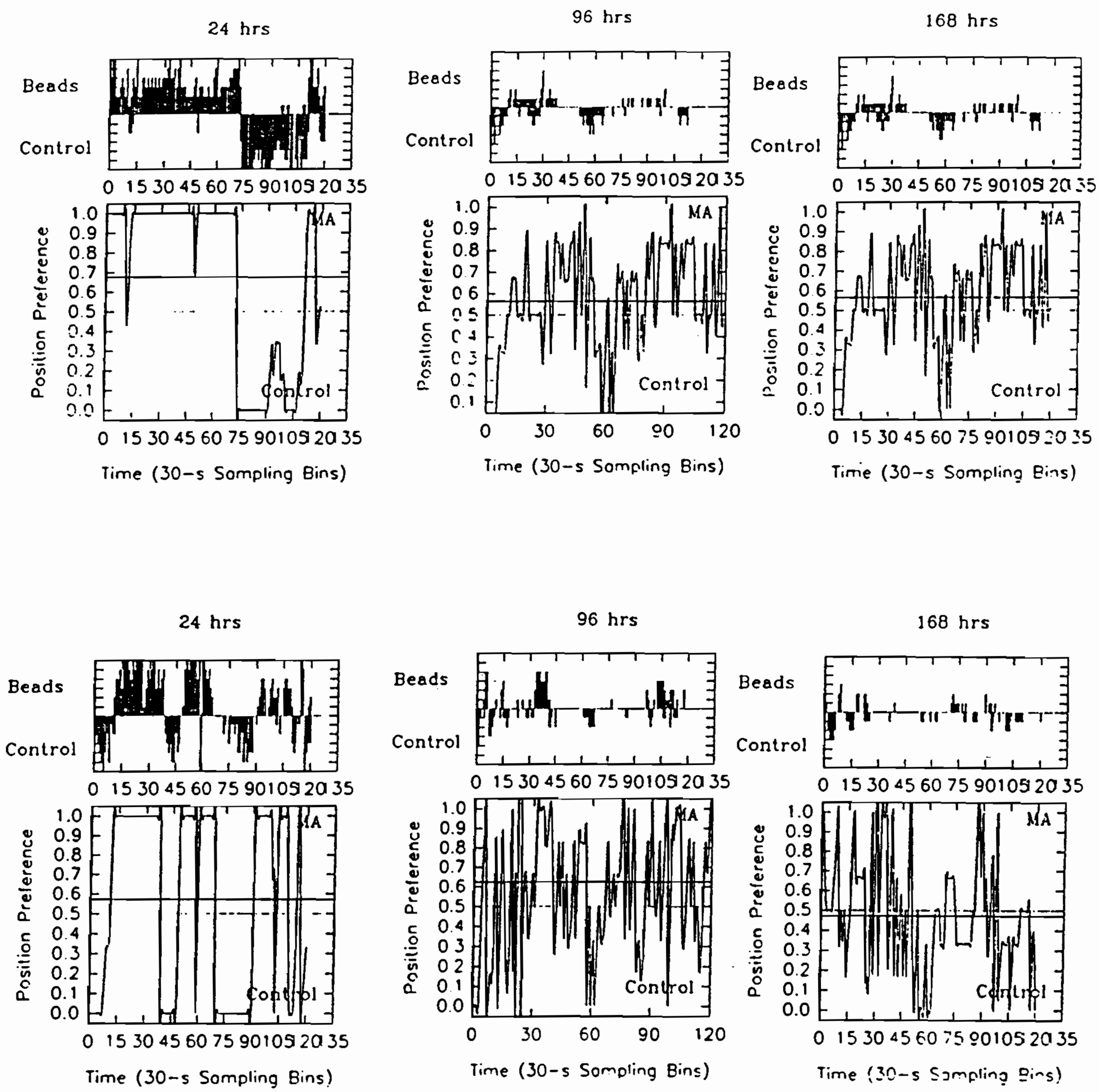


Figure VII-3-2. Behavioral records for the second treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA beads. Negative values reflect the feeding intensity in the untreated portion of the pen. (Bottom) Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of 0 indicates that all ducks were on the control side. A score of 0.5 indicates that half the ducks were on either side of the pen.

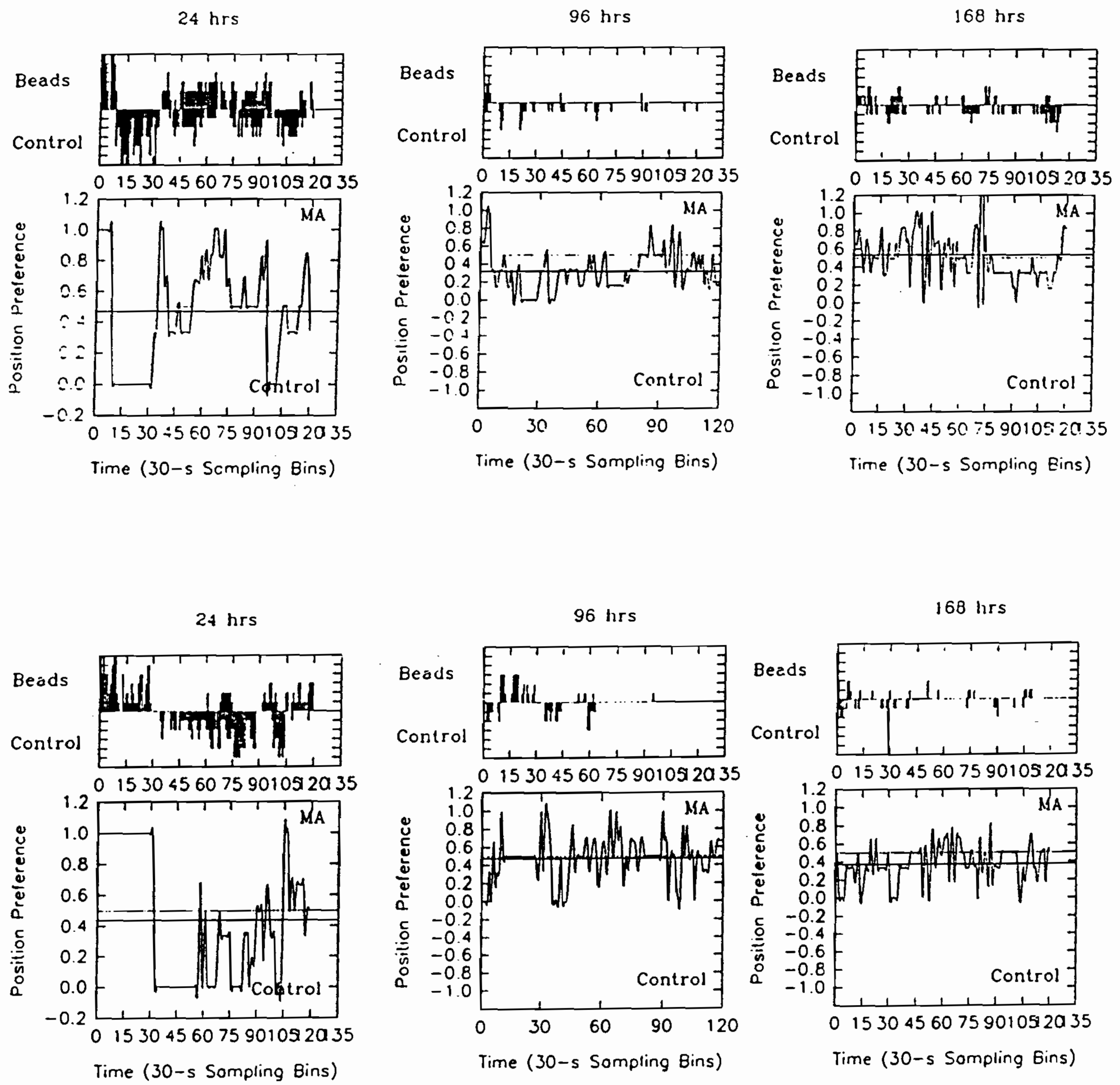


Figure VII-3-2 (cont.). Behavioral records for the second treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA beads. Negative values reflect the feeding intensity in the untreated portion of the pen. (Bottom) Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of 0 indicates that all ducks were on the control side. A score of 0.5 indicates that half the ducks were on either side of the pen.

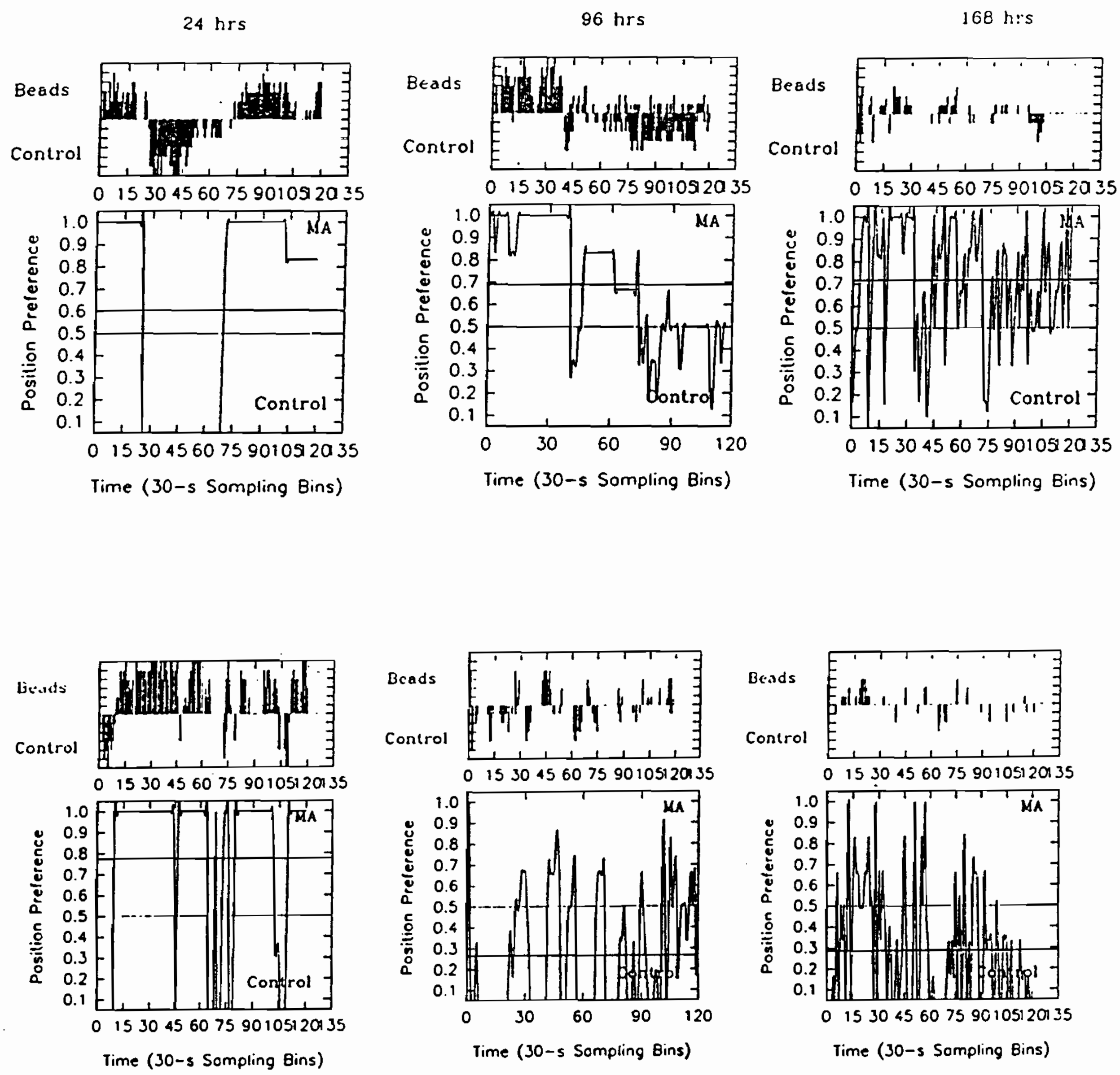


Figure VII-3-2 (cont.). Behavioral records for the second treatment period, showing the six replicate observations for each of six pens. (Top) Frequency of feeding activity as a function of exposure for six ducks in observation pens. Positive values reflect the feeding intensity on the half of the pen treated with MA beads. Negative values reflect the feeding intensity in the untreated portion of the pen. (Bottom) Position preference of ducks as a function of exposure time per session. A score of 1.0 indicates that all ducks were on the side of the pen treated with beads, while a score of 0 indicates that all ducks were on the control side. A score of 0.5 indicates that half the ducks were on either side of the pen.

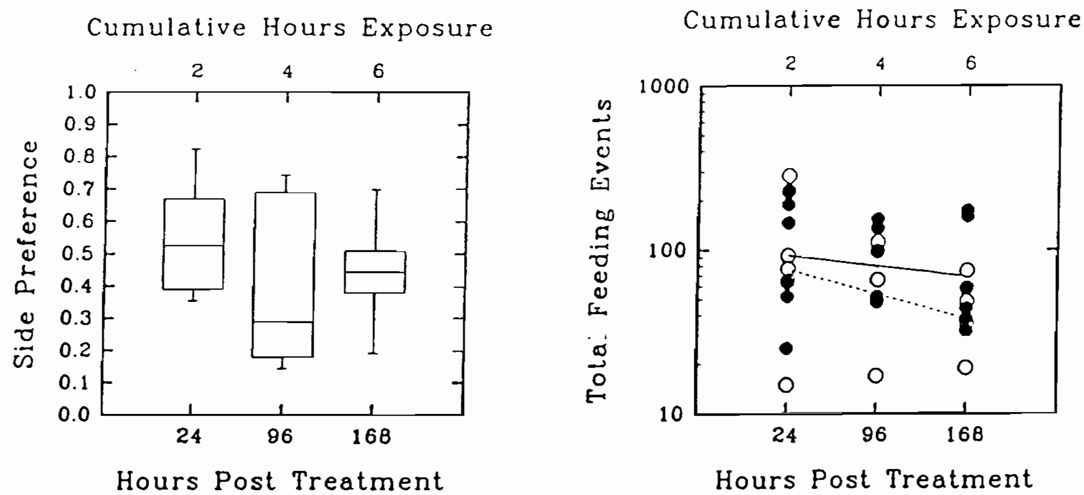


Figure VII-3-3. (Left) Summary box plot of side preference of ducks as a function of hours since initial treatment and hours of accumulated feeding experience for the first treatment period. The figure codes are as follows: mean (horizontal dashed line), median (horizontal solid line), 95% confidence limit (box), range (vertical capped lines). (Right) Feeding frequency as a function of hours since treatment and cumulative feeding experience of ducks for the first treatment period. Open circles depict feeding activity in the bead-treated area of the pen, while the dashed line depicts the regression. Solid circles depict feeding activity in the control area of the pen, while the solid line depicts the regression.

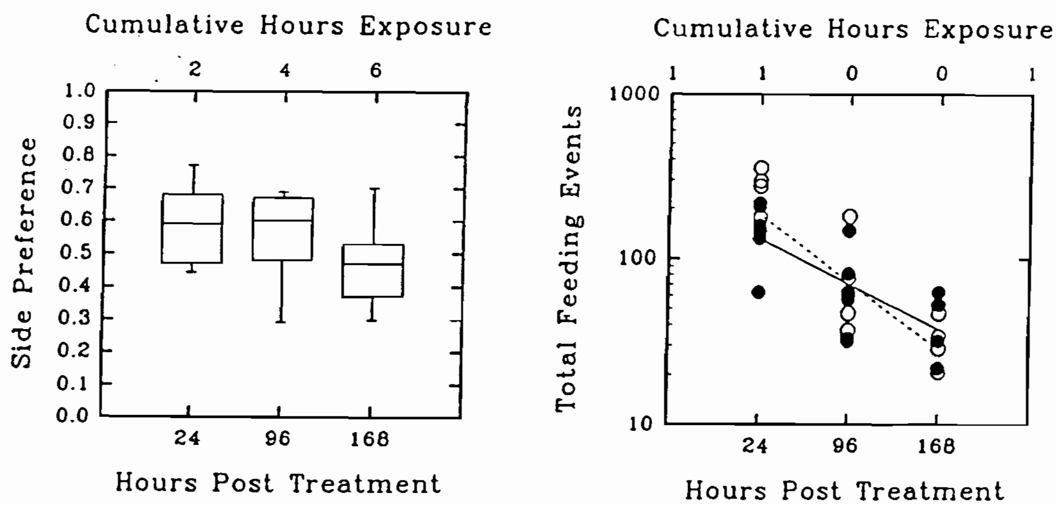
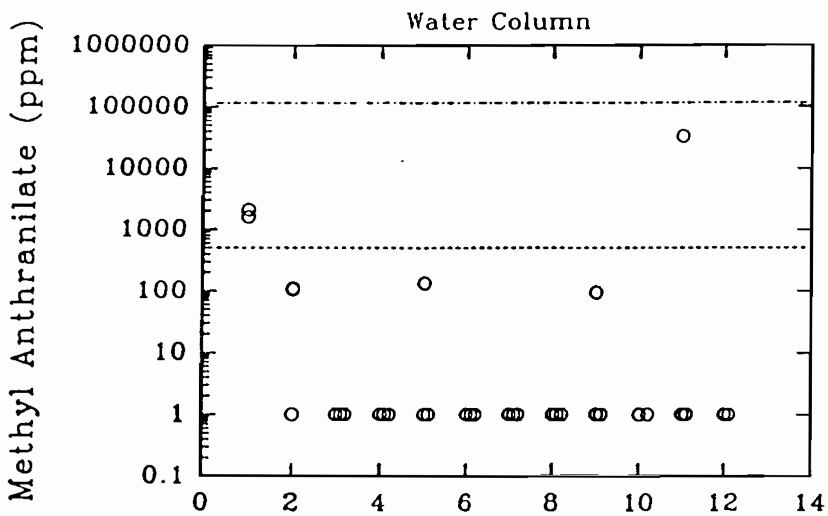


Figure VII-3-4. (Left) Summary box plot of side preference of ducks as a function of hours since initial treatment and hours of accumulated feeding experience for the second treatment period. The figure codes are as follows: mean (horizontal dashed line), median (horizontal solid line), 95% confidence limit (box), range (vertical capped lines). (Right) Feeding frequency as a function of hours since treatment and cumulative feeding experience of ducks for the second treatment period. Open circles depict feeding activity in the bead-treated area of the pen, while the dashed line depicts the regression. Solid circles depict feeding activity in the control area of the pen, while the solid line depicts the regression.



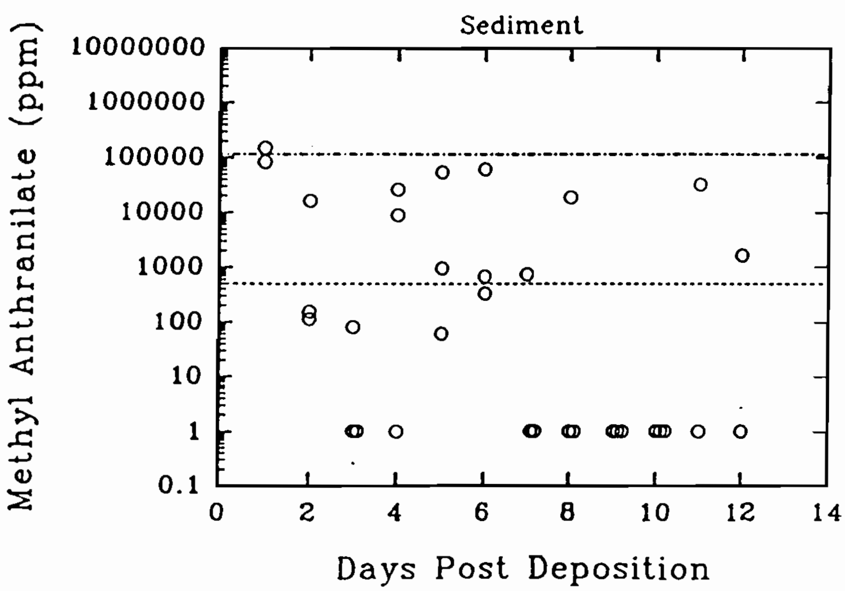


Figure VII-3-5. (Top) HPLC assay for MA content of beads suspended near the surface of the water in situ at Eagle River Flats as a function of time of exposure. The horizontal dashed-dotted line depicts the MA content of beads at time zero. The horizontal dashed line depicts the normal lower limit (500 ppm) for repellency. (Bottom) HPLC assay for MA content of beads deposited in the sediment in situ at Eagle River Flats as a function of time of exposure. The codes are the same as above.

sediment improves the longevity considerably (Fig. VII-3-5 bottom). Effective levels of MA were recovered up to 12 days post-deposition. However, effective levels of MA began to drop precipitously by 7 days post-deposition, and for all practical purposes this must represent the effective life span of this DP formulation. The estimated life span of the beads is consistent with the behavioral observations, which show continued suppression of feeding activity up to 7 days post-treatment. It is unlikely that the treatment would be effective for a longer period of time in the context of this experiment. Besides the natural degradation due to diffusion and microbial deterioration of MA, the number of particles left intact after three successive feeding bouts must certainly be diminished, though to what extent is unknown.

FALL 1993

The objective of the fall study was to test the effects of a formulation that yielded a tighter cross-linkage within the bead matrix, thus presumably inhibiting the rate of diffusion across the membrane boundary. The fall study was also intended to move the testing phase away from pen studies to open field studies, testing whether we could prevent free-ranging ducks from using treated sections of marsh.

The original SE formulations were effective up to seven days, but because the MA was dissolved in food-grade silicone oil, an undesirable oil slick was apparent on the water's surface after ducks fed on a treated area. The DP1 series of formulations solved the problem of the oil slick but were ineffective as repellents, either because of size variation, changes in rupture characteristics or more permeable membranes. The DP2 series of formulations were effective for about seven days in the field and had the appropriate degradation characteristics. The fall field trials were designated for testing the JR series of formulations. The JR series had substantially longer projected lives than any of the previous series (Table VII-3-1).

During the fall field season, too few ducks were present on the marsh at any given time to warrant testing. Under regulatory constraints we are restricted to treating only one acre of wetland for experimental purposes. Because daily censuses of ducks showed only 300–500 ducks on the 2500-acre marsh from mid-August to early September, any attempt to evaluate the beaded repellent's

Table VII-3-1. HPLC half-life estimates of beaded formulations under prescribed laboratory conditions.

Formulation	*Half-life (min)*
SE92-1*	120
SE92-2	24
DP92-1*	635
DP93-1*	311
DP93-2	48
JR93-1	122
JR93-2*	134
JR93-7	1136
JR93-8	781
JR93-9**	1387

* Indicates formulations used in the field.
**Indicates use in winter trials.

effect on free-ranging ducks would be inappropriate. Thus, field trials were canceled, and an attempt was made to test the formulation at a site away from Eagle River Flats where duck pressure on treated areas would be predictable and high. A site has been selected at the Yazoo National Wildlife Refuge near Holandale, Mississippi. Wintering populations of mallards and green-winged teal number from 150,000–200,000 birds. The test is scheduled to take place from 5 to 25 January 1994.

CONCLUSIONS AND RECOMMENDATIONS

Encapsulated formulations of MA can be effective at reducing feeding activity. Subsequent formulations are being considered that show greater promise for stability in the field. Changing the outer wall to alginate materials cross-linked with tannic acid will decrease the permeability to MA. Reincorporating the core to a gelled silicone oil/MA mix will further retard leaching from the capsule. If the initial concentration of a capsule is 15% MA and a half-life of ten days can be achieved, we estimate that the capsules will retain their effectiveness in the field for the duration of the spring or fall migratory period. Thus, only one application will be necessary each spring and each fall.

Based upon field studies where geese have been moved off MA-treated turf, we anticipate that free-ranging ducks can be moved off treated sediments.

Limited field trials to test this hypothesis are planned for FY94. Based on differential feeding activity of treated and untreated areas, differential use of treated and untreated areas, the probability of encountering a WP particle and the minimum toxic dose, we will be able to estimate the relative risk of WP poisoning for free-ranging ducks. This model will be useful in evaluating application strategies for short-term remediation efforts.